

Claims

1. A method of writing a photo-induced structure into a photosensitive material substrate, the method comprising the steps of:
 - creating an interference pattern utilising at least two light beams,
 - exposing the substrate to the interference pattern for photo-inducing material changes in the substrate, and
 - creating an irregularity in the interference pattern by controlling a wavefront of at least one of the beams, for creating a functional defect in the photo-induced structure.
2. A method as claimed in claim 1, wherein the step of controlling the wavefront of at least one of the beams comprises utilising adaptive optics means for altering the wavefront.
3. A method as claimed in claim 2, wherein the adaptive optics means is a reflective or transmissive adaptive optics means.
4. A method as claimed in claims 2 or 3, wherein the adaptive optics means comprises a micro electronic mechanical system (MEMS) device.
5. A method as claimed in claim 4, wherein the MEMS device comprises an array of movable micro mirrors.
6. A method as claimed in claims 2 or 3, wherein the adaptive optics means comprises a transmissive device based on one or more of a group comprising liquid crystal technology, ferroelectric liquid crystal technology, and electrically controllable ferroelectric liquid crystal retarder plates.
7. A method as claimed in any one of claims 1 to 5, wherein the or an adaptive optics means for controlling the wavefront is further utilised to split an incoming light beam to create the at least two light beams for creation of the interference pattern.
8. A method as claimed in any one of the preceding claims, wherein the functional defect comprises a linear defect, whereby the resulting 1-dimensional photo-induced structure exhibits a transmission resonance.
9. A method as claimed in any one of the preceding claims, wherein the method comprises creating a 2-dimensional or 3-dimensional interference pattern.

10. A method as claimed in claim 9, wherein the functional defect comprises a 2-dimensional or 3-dimensional defect.

11. A method as claimed in claim 10, wherein the 2-dimensional or 3 dimensional defect comprises an extended defect.

12. A method as claimed in any one of the preceding claims, wherein the functional defect comprises a dislocation defect, whereby the resulting photo-induced structure is asymmetric.

13. A method as claimed in any one of the preceding claims, wherein the method further comprises the steps of:

- inducing a relative movement between the substrate and an interference region of the beams,
- controlling a relative phase difference between the beams to induce changes in the interference pattern, and
- controlling a velocity of the changes in the interference pattern to write an extended photo-induced structure in the substrate.

14. A method as claimed in claim 13, wherein the relative movement is effected through movement of the substrate and/or scanning of the beams.

15. A method as claimed in claims 13 or 14, wherein the relative movement is effected through a combination of movement of the substrate and simultaneous scanning of the beams in a direction transverse to the movement of the substrate.

16. A method as claimed in any one of claims 13 to 15, wherein the method further comprises the step of further controlling the wavefront of at least one of the beams as a function of the relative movement, whereby the position and/or size and/or shape of the functional defect along the resulting photo-induced extended structure is controlled.

17. A method as claimed in any one of claims 13 to 16, wherein the method further comprises the step of controlling the wavefront of at least one of the beams to change the number of defects created along the photo-induced extended structure.

18. A method as claimed in any one of the preceding claims 13 to 17, wherein the method further comprises the step of controlling the relative phase difference between the beams to vary a pitch of the interference pattern, or to vary a contrast of the interference pattern.

19. A method as claimed in claim 18, wherein the contrast of the interference pattern is controlled to be zero for writing a photo-induced refractive structure.

20. A method as claimed in any one of the preceding claims, wherein the method further comprises the step of shaping the beams to control the exposure of the substrate to the interference pattern.

21. A method as claimed in claim 20, wherein the adaptive optics means is utilised in the shaping of the beams.

22. A method as claimed in any one of the preceding claims, wherein the method further comprises the step of focusing the light beams in the interference region.

23. A method as claimed in any one of the preceding claims, wherein the method further comprises the step of applying feedback corrections during the writing of the photo-induced structure, to achieve desired characteristics of the written photo-induced structure.

24. A method as claimed in claim 23, wherein the feedback corrections are conducted utilising a computer controlled process.

25. A method as claimed in any one of the preceding claims, wherein the photosensitive material substrate has a non-linear photosensitivity, and one or more of the beams are pulsed laser beams, whereby a three-dimensional photo-induced structure can be written in the substrate utilising intensity variations in the created interference pattern.

26. A method as claimed in claim 25, wherein the material change comprises a refractive index change, change in solubility, change in density, change in light transmission/absorption, and/or change in susceptibility to the next technological process.

27. A method as claimed in any one of the preceding claims, wherein the method further comprises the step of controlling the polarisation of at least one of the light beams.

28. A method as claimed in claim 18, wherein the adaptive optics means is utilised in the controlling of the relative phase difference.

29. An interferometer for writing a photo-induced structure into a photosensitive material substrate, the interferometer comprising:

- an interference unit arranged for creating an interference pattern utilising at least two light beams, and
- a control unit for controlling a wavefront of at least one of the beams to create an irregularity in the interference pattern for creating a functional defect in the photo-induced structure.

30. An interferometer as claimed in claim 29, wherein the control unit comprises an adaptive optics element for controlling the wavefront of at least one of the beams for altering the wavefront.

31. An interferometer as claimed in claim 30, wherein the adaptive optics element is a reflective or transmissive adaptive optics element.

32. An interferometer as claimed in claims 30 or 31, wherein the adaptive optics element comprises a micro electronic mechanical system (MEMS) device.

33. An interferometer as claimed in claim 32, wherein the MEMS device comprises an array of movable micro mirrors.

34. An interferometer as claimed in claims 30 or 31, wherein the adaptive optics element comprises a transmissive device based on one or more of a group comprising liquid crystal technology, ferroelectric liquid crystal technology, and electrically controllable ferroelectric liquid crystal technology retarder plates.

35. An interferometer as claimed in any one of claims 29 to 34, wherein the or an adaptive optics element for controlling the wavefront is further arranged for splitting an incoming light beam to create the at least two light beams for creation of the interference pattern.

36. An interferometer as claimed in any one of claims 29 to 35, wherein the control unit is further arranged for controlling a relative phase difference between the beams to induce changes in the interference pattern, and to control a velocity of the changes in the interference pattern to write an extended photo-induced structure in the substrate.

37. An interferometer as claimed in any one of claims 29 to 36, wherein the interferometer further comprises a scanning unit for scanning of the beams during the writing of the photo-induced structure.

38. An interferometer as claimed in claim 36, wherein the control unit is further arranged for controlling the wavefront of at least one of the beams as a function of the relative movement in a manner such as to control the position and/or size and/or shape of the functional defect along the resulting photo-induced extended structure.

39. An interferometer as claimed in claims 36 or 38, wherein the control unit is further arranged for controlling the wavefront of at least one of the beams to change the number of defects created along the photo-induced extended structure.

40. An interferometer as claimed in any one of claims 36, 38 or 39, wherein the control unit is further arranged for controlling the relative phase difference between the beams to vary a pitch of the interference pattern, or to vary a contrast of the interference pattern.

41. An interferometer as claimed in claim 40, wherein the control unit is arranged to utilise the adaptive optics element for the controlling of the relative phase difference.

42. An interferometer as claimed in any one of claims 29 to 41, wherein the interferometer further comprises a beam shaping unit for shaping the beams to, in use, control the exposure of the substrate to the interference pattern.

43. An interferometer as claimed in claim 42, wherein the beam shaping unit comprises the or an adaptive optics element.

44. An interferometer as claimed in any one of claims 29 to 43, wherein the interferometer further comprises a focusing unit for focusing the light beams in the interference region.

45. An interferometer as claimed in any one of claims 29 to 44, wherein the interferometer further comprises a feedback unit for applying feedback corrections during the writing of the photo-induced structure, to achieve desired characteristics of the written photo-induced structure.

46. An interferometer as claimed in claim 45, wherein the feedback unit comprises a computer processor.

47. An interferometer as claimed in any one of claims 29 to 46, wherein the photosensitive material substrate has a non-linear photosensitivity, and one or more of the beams are pulsed laser beams, whereby a three-dimensional photo-induced structure can be written in the substrate utilising intensity variations in the created interference pattern.

48. An interferometer as claimed in any one of claims 29 to 47, wherein the control unit is further arranged, in use, to control the polarisation of at least one of the light beams.

49. A photo-induced structure written into a photosensitive material substrate utilising the method as claimed in any one of claims 1 to 28 or the interferometer as claimed in any one of claims 29 to 48.

50. A method of writing a photo-induced structure into a photosensitive material substrate, substantially as herein described with reference to the accompanying drawings.

51. An interferometer for writing a photo-induced structure into a photosensitive material substrate, substantially as herein described with reference to the accompanying drawings.